Name ____

Lights, Camera….Action Potential!

INTRODUCTION:
In this activity, you will set up a model to simulate how action potentials are generated in neurons. You will investigate the role of sodium/potassium pumps in maintaining resting potentials as well as how sodium and potassium channels are involved in the cell's depolarization and hyperpolarization.

MATERIALS:
- Cell membrane of axon
- Red Sodium channels (open and closed)
- Blue Potassium channels (open and closed)
- Purple Sodium/Potassium Pumps
- Red beads (Sodium ions)
- Blue beads (Potassium ions)
- Post Its
- Stop watch

PROCEDURE:
<u>Part A: Setting up your Neuron</u>
1. Orient your neuron so the outside of the cell is facing the front of the room and the inside of the cell is facing the back of the room
2. Place 2 sodium/potassium pumps on the left-hand portion of your cell membrane (One should have sodium in it and one should have potassium in it)
3. Place a closed sodium channel to the right of the pumps
4. Place a closed potassium channel to the right of the sodium channel
5. Distribute your sodium and potassium ions on either side of the cell membrane until you have about the same number of each ion inside and outside the cell

<u>Part B: Establishing Resting Potential</u>
1. Pump <u>**3**</u> sodium ions (Na^+) out of the cell for every <u>**2**</u> potassium ions (K^+) pumped into the cell (via the sodium potassium pumps)
   - Remember, this requires energy!
2. Continue doing so until you only have about 15 sodium ions (Na^+) on the inside of the cell
3. Given that both ions being pumped are positive, compare the number of ions outside the cells vs inside. Using the Post-Its, label which side of the cell is now positively charged (+) vs negatively charged (-)
4. Answer analysis questions #1-4

Part C: Depolarization

1. Sodium channels will open first, initiating an action potential. Replace your closed sodium channel with an open sodium channel.
2. A sodium channel opens for about one millisecond. To represent this, your sodium channel in the simulation will stay open for 10 seconds. Based on your answer to analysis question #3, drag sodium ions through the sodium channel one at a time in the direction you think they will go until 10 seconds have passed.
3. Using the Post-Its, label which side of the cell is now positively charged (+) vs negatively charged (-)
4. Answer analysis questions #5-6

Part D: Hyperpolarization

1. Sodium channels will then close and the potassium channels will open. Replace your open sodium channel with a closed sodium channel and your closed potassium channel with an open potassium channel.
2. A potassium channel opens for one to three milliseconds. To represent this, your potassium channel in the simulation will stay open for 10 seconds. Based on your answer to analysis question #4, drag potassium ions through the potassium channel one at a time in the direction you think they will go until 10 seconds have passed.
3. Using the Post-Its, label which side of the cell is now positively charged (+) vs negatively charged (-)
4. Answer analysis questions #7-8

Part E: Reestablishing Resting Potential

1. Replace your open potassium channel with a closed potassium channel.
2. Repeat steps 1-3 from Part B to reestablish the cell membrane's resting potential
3. When you are finished, clean up and answer the questions in the conclusion and extension sections (you may use your notes to help you)

ANALYSIS:

Part B

1. Once the resting potential is established, where is there a higher concentration of each of the following:
    - Na^+ ______________________
    - K^+ ______________________

2. Indicate the charge on each side of the cell membrane
    - Inside the cell ______________________
    - Outside the cell ______________________

3. If the sodium ions were allowed to move across the cell membrane, which direction would they tend to move based on their concentration: into or out of the cell? Explain

4. If the potassium ions were allowed to move across the cell membrane, which direction would they tend to move based on their concentration: into or out of the cell? Explain

<u>Part C</u>

5. Look at the numbers of sodium ions on each side of the cell membrane now. Compared to the number on each side of the cell membrane at rest, are there more or less sodium ions inside the cell than there were before? Explain

6. Based on your answer to question 5, do you think the inside of the cell is more negative or positive than it was before? Explain

<u>Part D</u>

7. Look at the numbers of potassium ions on each side of the cell membrane now. Compared to the number on each side of the cell membrane at rest, are there more or less potassium ions inside the cell than there were before? Explain

8. Based on your answer to question 7, do you think the inside of the cell is more negative or positive than it was before you opened the potassium channel (but after you had opened the sodium channel)? Explain

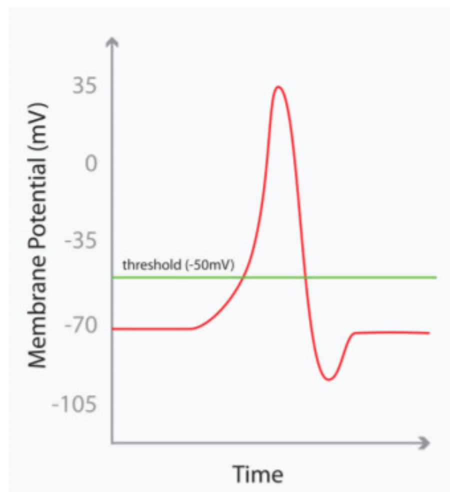
CONCLUSION:

9. What is the ratio of sodium ions to potassium ions that are moved through the sodium/potassium pump each cycle? In what direction is each ion pumped?

10. Is the sodium/potassium pump an example of passive or active transport? Explain

11. Is the transport of ions through the sodium and potassium channels an example of passive or active transport? Explain

12. A reduction in the magnitude of the membrane potential is called ____________________.
Label this on the graph to the right. This occurs when the cell membrane is permeable to _________ ions. As a result the inside of the cell is ______ negative/_______ positive than the outside of the cell.



13. An increase in the magnitude of the membrane potential is called ____________________.
Label this on the graph to the right. This occurs when the cell membrane is permeable to _________ ions. As a result the inside of the cell is ______ negative/_______ positive than the outside of the cell.

EXTENSION:

14. In the nerve cell axon, something happens called sodium channel inactivation. This means that after the sodium gates open and close, they cannot open again for a few milliseconds and a second action potential cannot be initiated yet.
    - What is this period of time called?
    - What does this ensure?

15. The simulation you have completed is with a model of an unmyelinated neuron. How would a myelinated neuron simulation differ? Explain